SCP-CDMA GSO,s System Proposal

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Abstract - **The practical implementation of the SCP approach leads to the problem of pilots transmission through the same propagation environment as that of the cooperative information signals. The requirements to the pilot transmission technology are defined in the report. A proposal for CDMA pilot spreading and transmission in the frequency band of the information signal is given too. The basic SCP-CDMA systems parameters are defined by means of modified link budget calculations per slot. Matlab matrix simulations of a SCP-CDMA system, K-u band version, used for S-DVB application, are given in the report too. The goal is to define the Spatial Cross Correlation Function (SCCF) between cooperative satellite and the others. It is calculated for 0, 30 and 60 degrees of the pilot tilt angles. The computed SCCF is in fact the virtual antenna pattern at baseband. Its sidelobes satisfy the satellite regulations levels and promise low BER properties for the future SCP-CDMA S-DVB systems.**

Keywords **– SCP technology, SCP-CDMA, S-DVB, Spatial cross correlation function**

I. Introduction

A description of a new radio-communication technology, based on random phased antenna arrays approach and autocorrelation signal processing (SCP), as well as Matrix presentations of the signals and the basic signal processing procedures, is given in Ref. 1 and Ref.2. The goal of this report is to propose a SCP-CDMA GSO,s system, as well as to simulate its SCCF (Spatial Cross Correlation Function) pattern.

II. Pilot signal transmission

The practical implementation of the SCP approach leads to the problem of pilots transmission through the same propagation environment as that of the cooperative information signals. The requirements to the pilot transmission technology could be summarized as follows:

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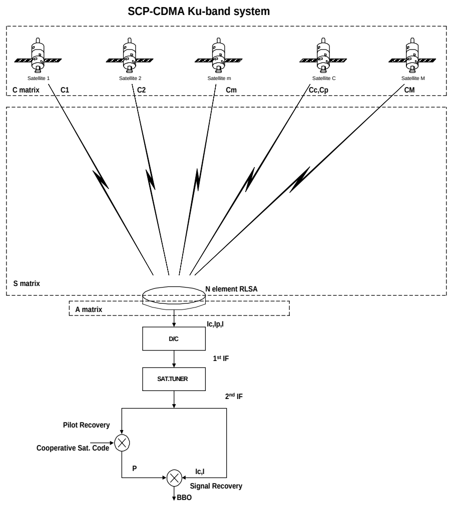

Fig.1

SCP system architecture

- It should occupy minimum additional frequency spectrum resources, as well as additional hardware.
- It should not cause interference over the cooperative information signals.
- It should ensure easy access to the chosen combination of pilots in the case of mass implementation of SCP technology in satellite communications.
- It should not generate any significant intermodulation noise in the satellite transponders, working near to the saturation point (zero back-off).
- Bearing in mind the frequency dispersive phase shifts, introduced by Radial Line Slot Antenna (RLSA) to the information and to the pilot signals, their career frequencies should be as close as it is possible.

The common used methods for access to the base stations resources in wireless communications are Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA). All of them could to be used for pilot transmission in SCP technology, but the CDMA approach (Ref.3) matches in the best way to the above mentioned requirements. The system architecture of a SCP-CDMA system is shown in Fig.1. Its frequency spectrum is shown in Fig.2.

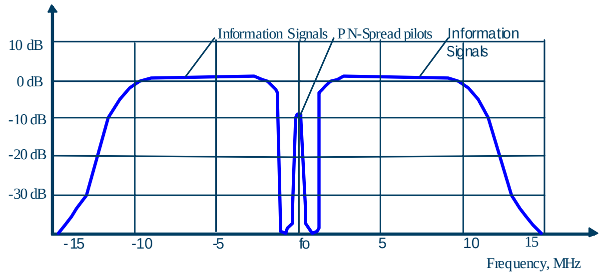

Fig.2. Frequency spectrum of SCP-CDMA system

III. SCP-CDMA GSO,S SYSTEM PARAMETERS

As a result of the random RLSA slots distribution and inclination, the different slots signals phases are random, uniformly distributed between 0 and 360 degrees. Their amplitudes can be calculated, using conventional link budget equations with the following assumptions for simplicity:

- The slot directivity pattern is omni directional (which is exactly correct for high elevation angles).
- The slot gain Gs=1,6 dbi (based on published experimental results for RLSA, the transmission losses in the antenna are included).
- Simplified forms of link budget equations are used (Ref.4).

Bearing in mind the above simplifications and the particular values for a S-DVB satellite:

- EIRP=50 dbw for each component of the QPSK modulated signals,
- S=38000 km (distance to the GSO satellite),
- f=12,5 GHz (microwave frequency in the midle of the Ku band),
- L=206 db (calculated propagation losses)
- R=20 MBt/s (standard information signal data rate),
- Rc=1,23 MCh/s (chosen spreading code chirp rate for the pilots),
- Receiver noise figure 1 db, antenna noise temperature 50 grad. K (equal to phase array antenna with the same aperture), system noise temperature Ts= 125 grad. K, Ts(db)=21 dbgrad.K,
- G/T per slot=-19,4 dbi/gradK (calculated),
- Ladd=2 db (additional losses due to propagation phenomena),
- Lpol.loss=3 db (because of the circular polarization),
- N=2700 (number of available slots in 60 cm diameter RLSA according to the published data), N(db)=34,3db

For the parameters listed above, the following values are computed:

- Information signal to noise ratio per slot (Eb/No)ips=-24,81 db.
- Information signal power per slot Cips=-159,4 dbW.

The multiplication of the information and the pilots signals from a given slot in the Correlator unit and the following Low Pass Filtering (LPF) is process of coherent demodulation. The result is N in phase base band components, which sum is the demodulated base band signal. Bearing in mind that the signal to noise ratio for the pilot is about 20 db higher than the same for the information signal (it is noise free), the total (Eb/No)t=N.(Eb/No)ips, (Eb/No)t(db)=N(db)+(Eb/No)(db)ips=34,3-24,81=9,49 db. The last result is several db above the specified in EN 300421 standard values.

In analogy the total figure of merit (G/T)t(db)=N(db)+G/T per slot(db)=34,3-19,4=14,9dbi/grad.K.

The thermal noise was calculated by means of standard procedure for PSK signals. The detailed SCP thermal noise properties are under investigation now and will be published soon.

IV. RADIAL LINE SLOT ANTENNA

It was shown that the SCP requirement to obtain smooth omnidirectional cooperative pattern needs the off-diagonal output signals to cancel for all possible elevation and azimuth angles of the cooperative satellite. It is zero when the antenna slots signals phase probability density function is uniform from 0 to 360 deg. for all spatial angles of the signal direction. A random distribution of the slots over RLSA surface was proposed for this purpose. The slots coordinates were chosen by means of random generator with some restrictions. The practical implementation of this procedure was not quite successful because:

- There were areas on the RLSA surface where the neighbour slots were at equal distance to the centre of the RLSA. As a result the signals from these slots are in phase (they are strong correlated) and the phase probability density function has maximum for low phase values.
- The neighbour slots were placed close and at equal distances each other in radial direction. Bearing in mind the low permittivity of the RLSA core, the signals from these slots were close in phase. The phase probability density function has maximum for low phase values too. The RLSA works as a leaky-wave antenna in this particular case.
- The small interslots spacing (used for high efficiency of the RLSA) leads to high values of mutual coupling among the neighbour slots. The result is the existence of high correlated areas on the RLSA surface, due to non-random phase excitement.

The existence of strong correlated areas leads to statistically uncompensated **cros** signal output (the BBO correlation matrix is not equal to its trace). The **cros** output is summed with the omnidirectional **cor** output and as a result the high ripples in the SCP output signal appear. It means that the system sensitivity is not equal for the different azimuth and elevation angles. The only way to obtain smooth SCP cooperative pattern is to decorrelate as much as it is possible the signals from the RLSA slots, bearing in mind the influence of the RLSA core, to receive with low signal to noise ratio (where the AWGN channel theory is valid) and to use digital correlators.

The latest algorithm for the slots distribution and orientation represents a combination of the previously used approaches for phase randomization and radial distributed pins fed slots with the following characteristics:

- random element position
- the slots are normal, or at angles ±45 deg to the radius of the antenna, or radial with exciting pins
- the positions of the exciting pins are alternatively changed so that the phase difference for the radial slots equally spaced from the antenna center and with different pins positions is 180 deg.

One of the most important parameters of the receiving S-DVB systems is the cross polarization isolation between Left and Right Hand Circular Polarization (LH, RH, CP). The problem here is its degradation for high tilt angles. The cross polarization isolation and the switching of the received polarizations in the SCP systems are based on entirely new principle of operation. The slots design assures the both CP to be received in the most efficient way. The choice of the polarization is based on the correlation of the chosen pair of pilots for given CP with the corresponding information signals. The signals, received by LH and RH CP, are not correlated because of the opposite direction of rotation and about 15 MHz frequency offset between the selected pilot signals and the opposite CP signals. Very good cross polarization properties, independent on the tilt angles, are expected in this way.

The developed math model of the SCP system, as well as the Mathlab simulations, do not include the polarization properties of the RLSA slots. As it was stated early, the best way to randomise the phase distribution is to incline the slots in random manner and to use circular polarization. The math description of the SCP approach in this case should to involve the antenna-wave interaction from polarization point of view. The detailed developing of this method for the SCP case should to be done in the future work.

The developed math model for the slots signals phases deals with the space distribution among antenna slots and the cooperative satellite (the outer solution), as well as the slots positions on the RLSA aperture (the inner solution). It does not include the influence of the inner slots and fed probes to the outer slots signal phases, as well as the mutual coupling phenomena.

V. SCP SYSTEM SIGNAL SIMULATIONS, KU-BAND S-DVB APPLICATION

The matrix simulations of a SCP-CDMA system, K-u band version, used for S-DVB application, should start with a simplified analysis. The goal is to define the Spatial Cross Correlation Function (SCCF - Ref.1) between cooperative satellite and others.

$$\mathbf{SCCF}(\phi,\theta)(dB) = 10\lg\left[\mathbf{BBO}_{\text{inter.}}(\boldsymbol{\varphi},\boldsymbol{\theta}) / \mathbf{BBO}_{\text{c}}\right]$$

For this purpose the following assumptions and simplifications are used in the calculations:

- space propagation losses $L_{snm} = 1$, $\lambda = 2{,}5cm$,
- $r_n = 5 - 28{,}5cm, \phi_n = 0 - 360^0$.
- ϕ_m, θ_m – angular coordinates of interference satellites, entries for S-matrix calculation, $\phi_c, \theta_c, \phi_p, \theta_p$ – angular coordinates of the cooperative satellite. Three possible scenarios should be calculated – in zenith, 30 and 60 degrees tilt from zenith, pure south.
- $c_1 = c_2 = ... = c_M = c_p = c_c = 1$ – amplitudes of interference, pilot and cooperative information signals.
- RLSA propagation losses $L_{an} = 1$. The phase shift due to inner slots and slot inclination $\Delta\varphi_n = 0$.
- The total receiver gain G=1.

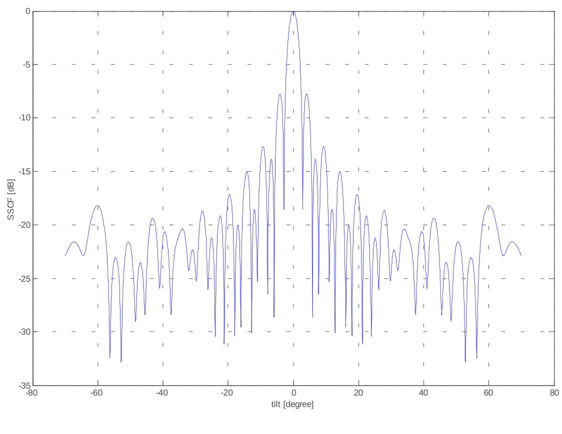

Fig.3. SCCF of RLSA Diameter – 0,57 m, N = 2501, $\lambda = 2{,}5$ cm, $\phi_p = 0^o, \theta_p = 0^o$, $\phi_m = 0^o, \theta_m = -70^o \div 70^o$

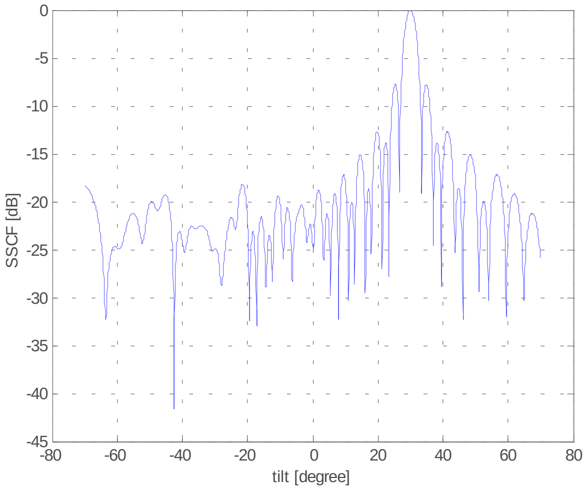

Fig.4. SCCF of RLSA Diameter – 0,57 m,
$N = 2501$, $\lambda = 2{,}5$ cm, $\phi_p = 0^o, \theta_p = 30^o$,
$\phi_m = 0^o, \theta_m = -70^o \div 70^o$

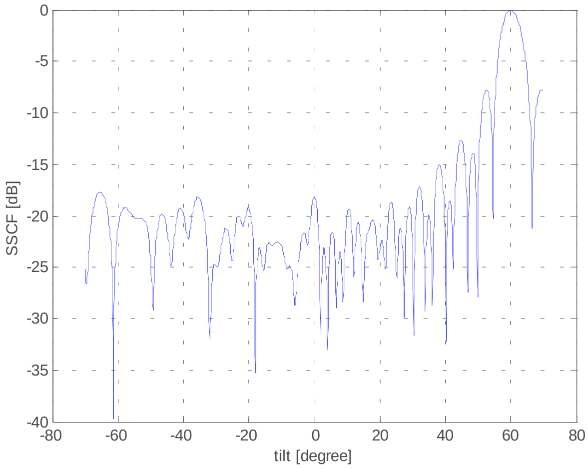

Fig.5 SCCF of RLSA Diameter – 0,57 m,
$N = 2501$, $\lambda = 2{,}5$ cm, $\phi_p = 0^o, \theta_p = 60^o$,
$\phi_m = 0^o, \theta_m = -70^o \div 70^o$

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